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(54) Etching a hole in an organic passivation layer for an LCD

(57) A contact hole in an organic passivation (or insulation) layer 129a (Fig 6D) including Si (eg benzocyclobutene) over an electrode 119b is plasma etched through a superimposed inorganic dielectric layer 129b (eg SiN_x or SiO_x) and a photoresist 143 by a CF_4/O_2 or SF_6/O_2 gas, the photoresist being ashed by the O_2. Alternatively (Fig 8D) the organic passivation layer 129a is partially etched by SF_6/O_2 gas until a thin layer remains and then etched by CF_4/O_2 gas, or completely etched by SF_6/O_2 gas followed by wet or dry etching.

FIG. 6D

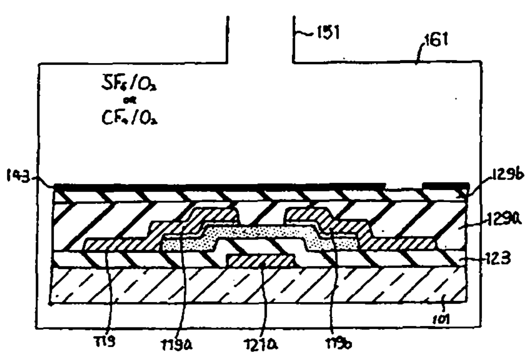

FIG. 8D

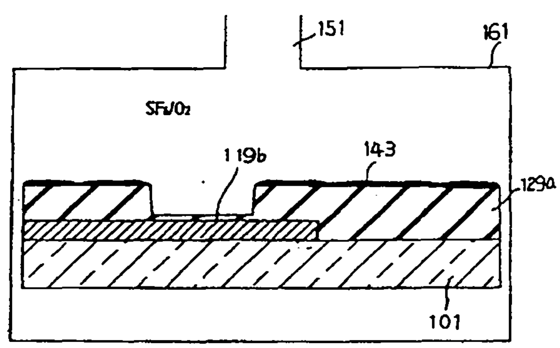

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FIG. 1

PRIOR ART

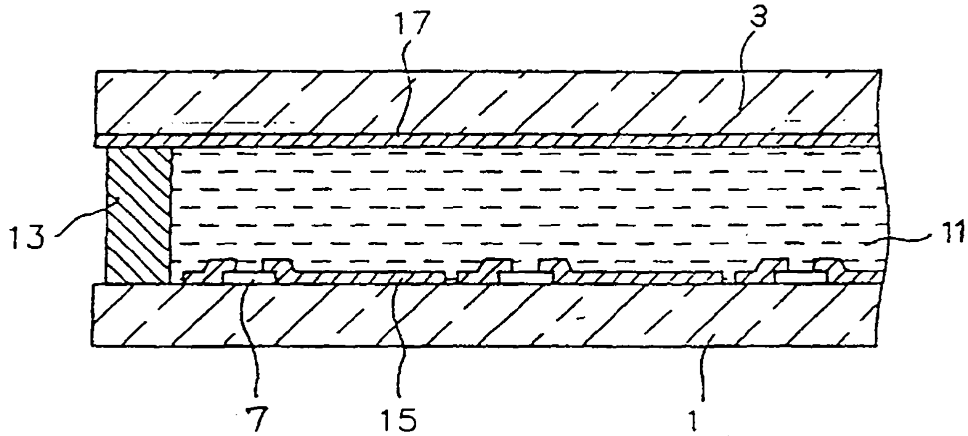


FIG. 3

PRIOR ART

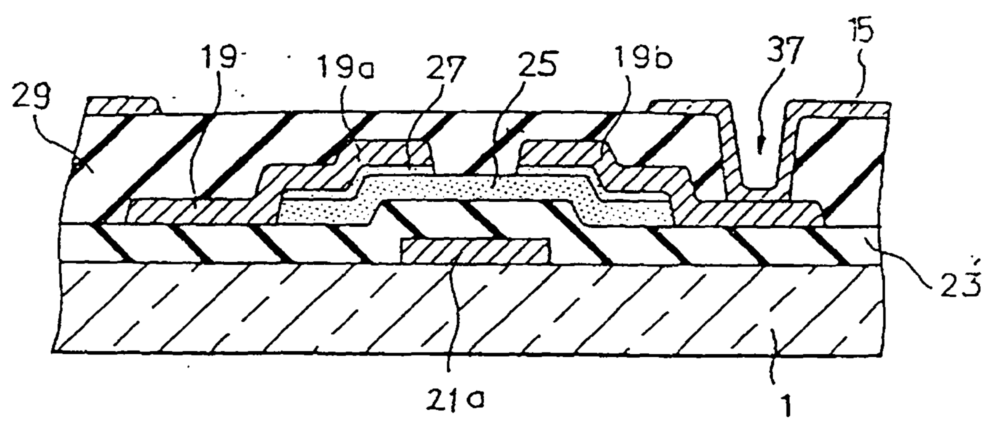


FIG. 2

PRIOR ART

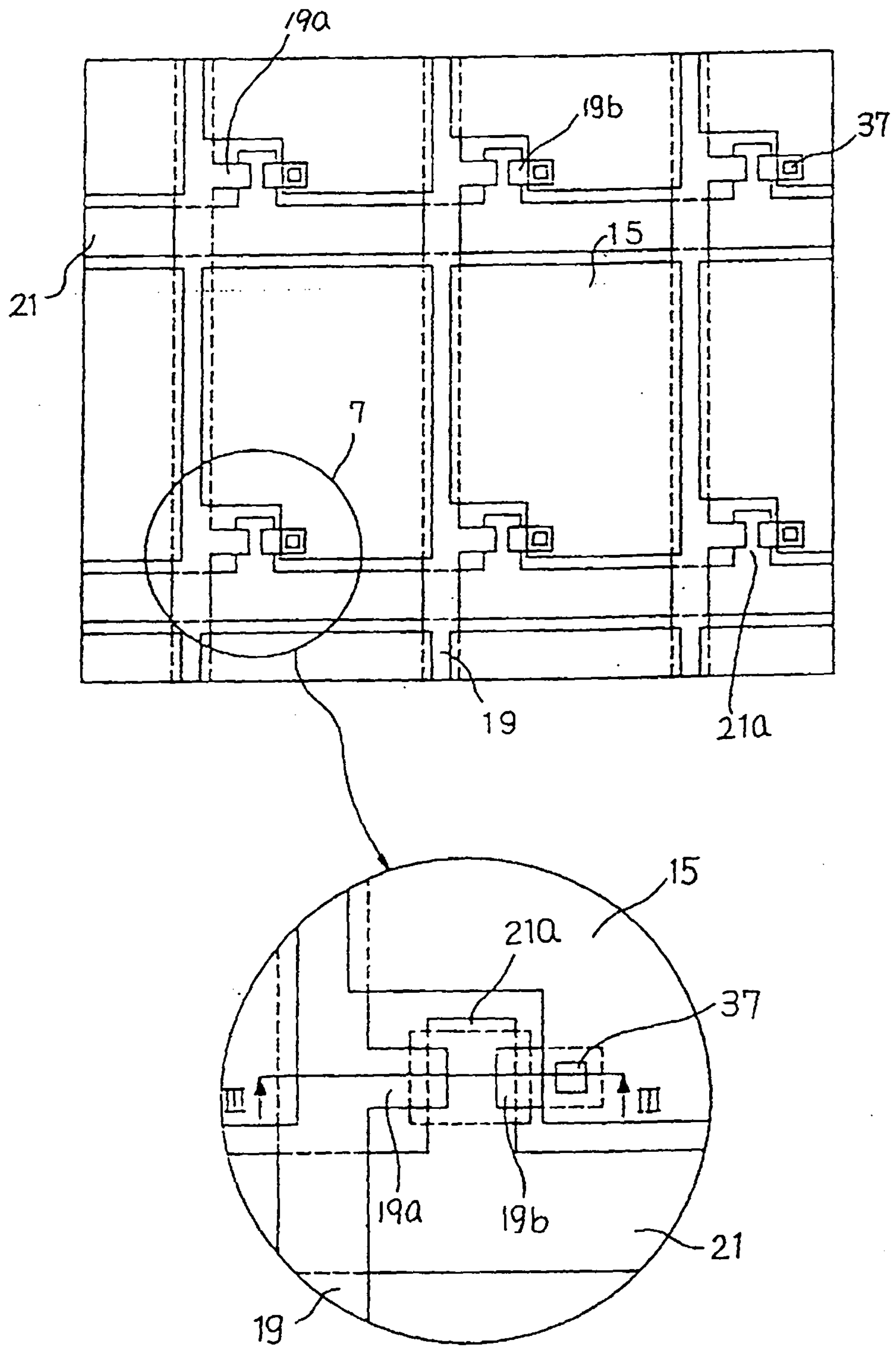


FIG. 4A

PRIOR ART

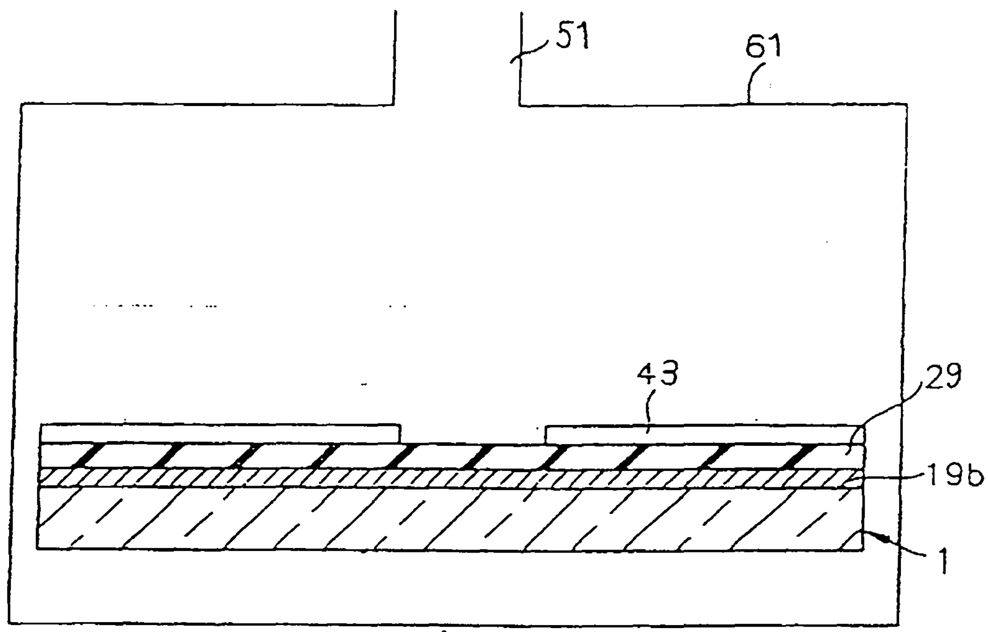


FIG. 4B

PRIOR ART

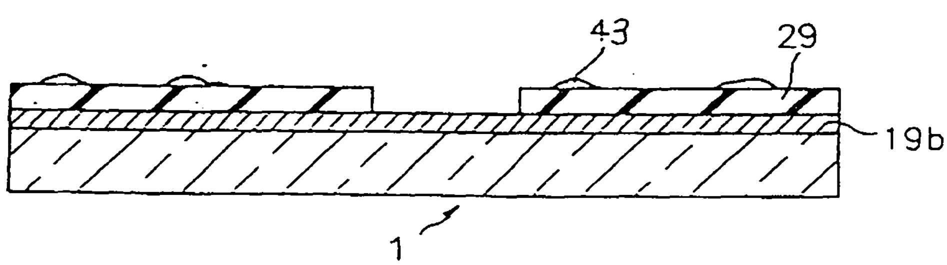


FIG. 5

PRIOR ART

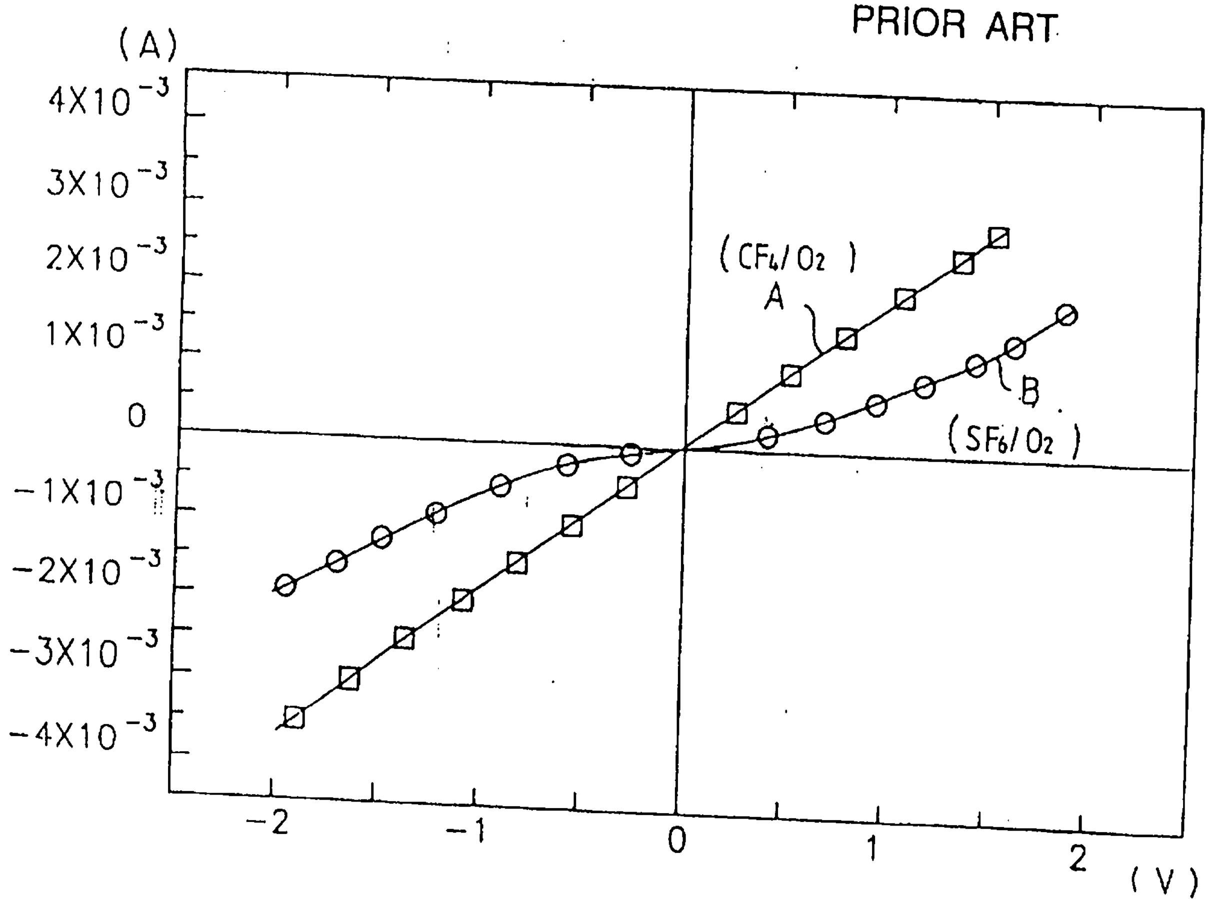


FIG. 6A

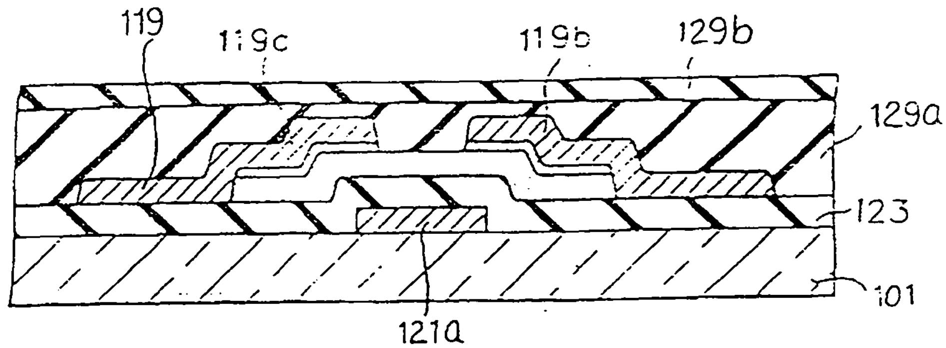


FIG. 6B

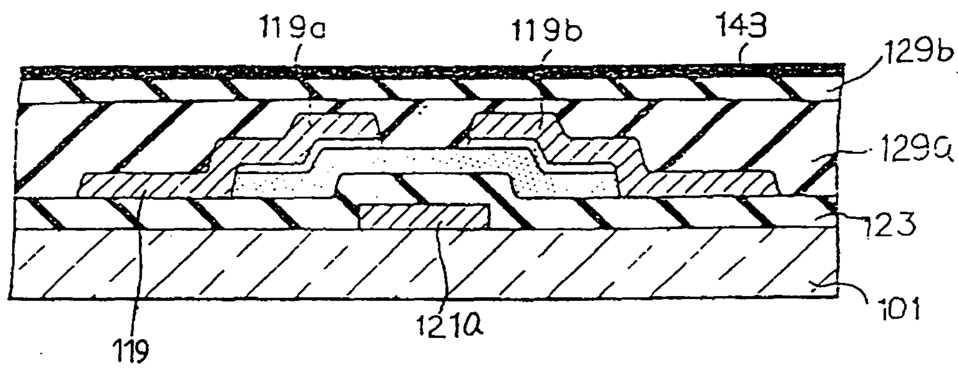


FIG. 6C

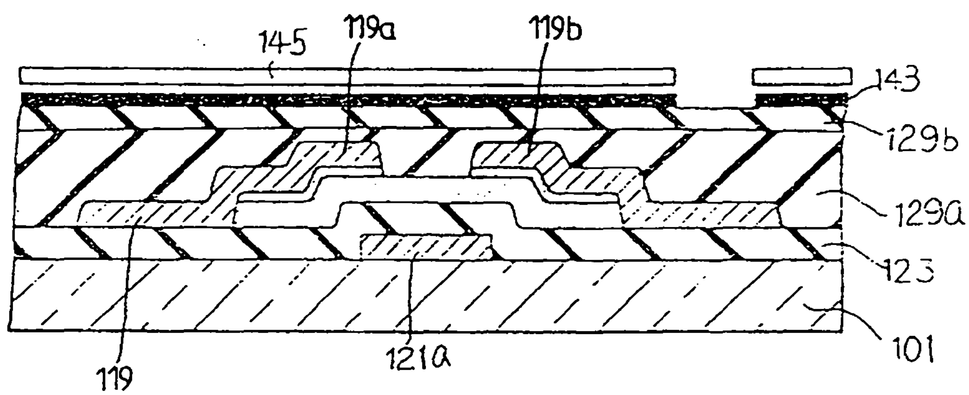


FIG. 6D

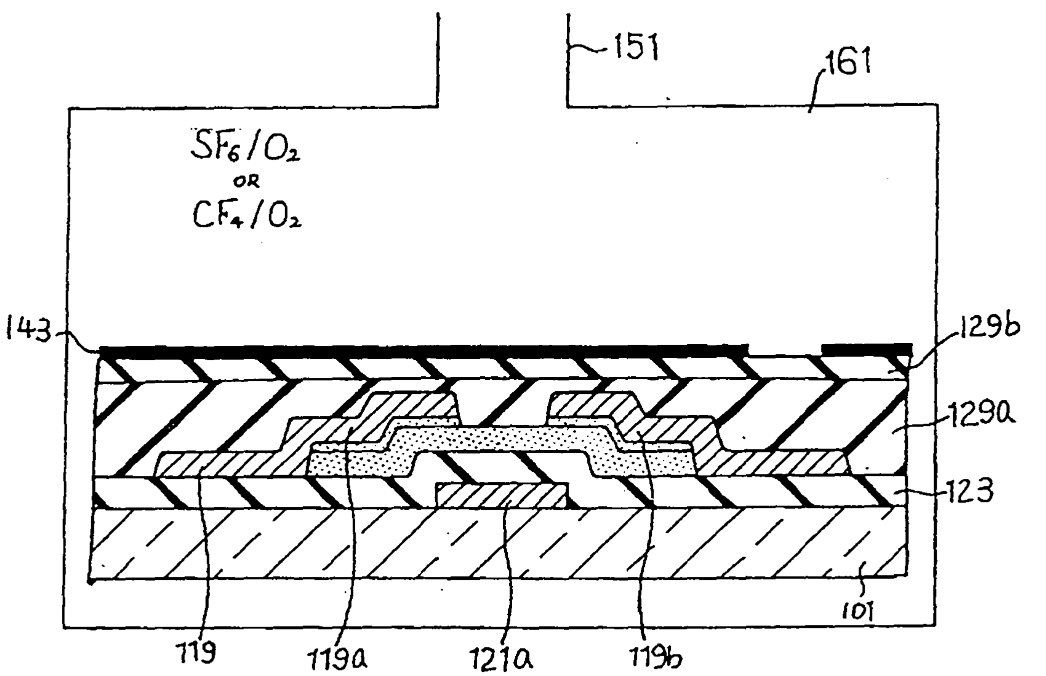

151
161
SF_6/O_2
OR
CF_4/O_2
143
129b
129a
123
101
119
119a
121a
119b

FIG. 6E

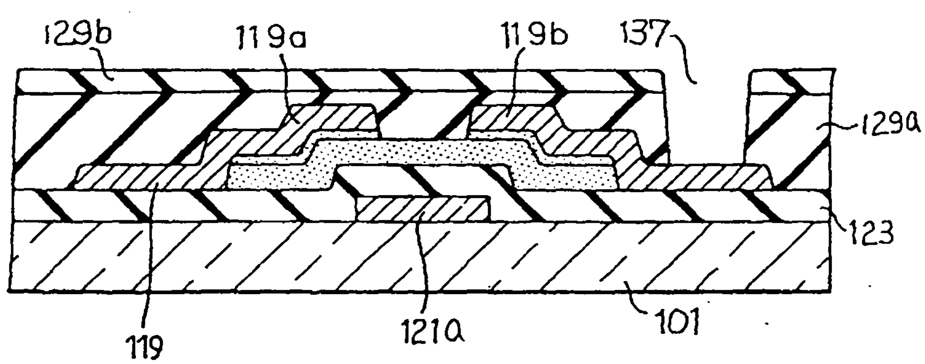

129b
119a
119b
137
129a
123
119
121a
101

FIG. 7

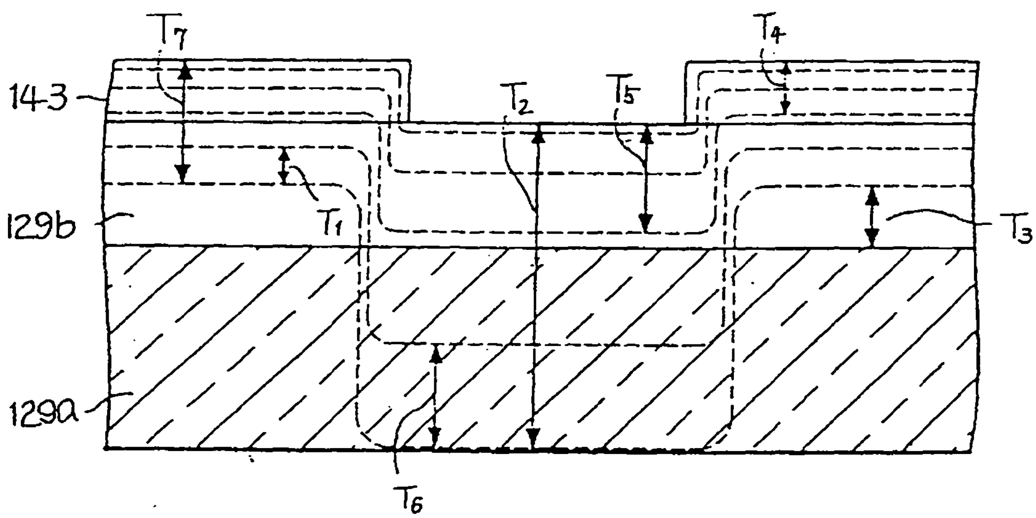


FIG. 8A

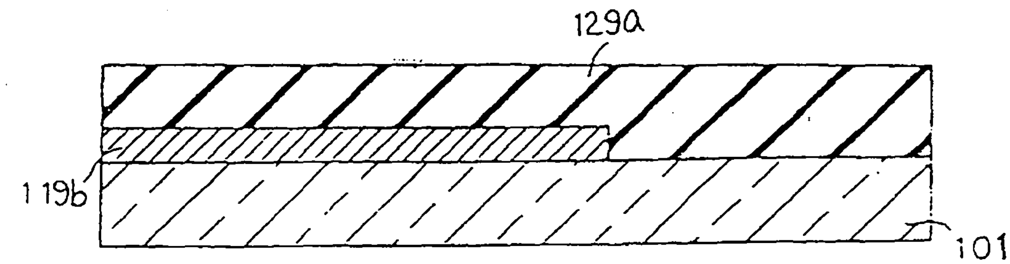


FIG. 8B

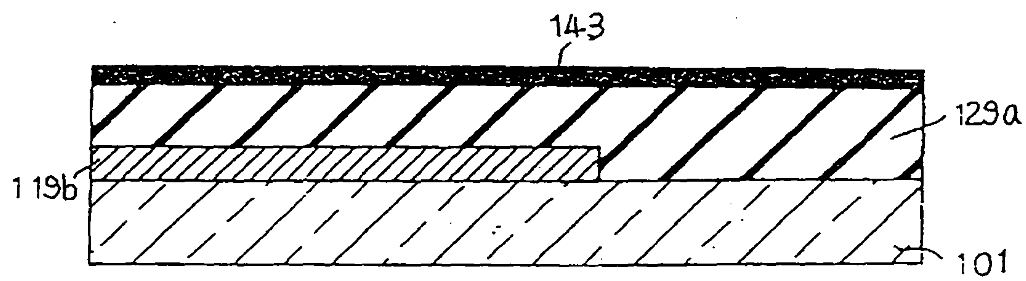


FIG. 8C

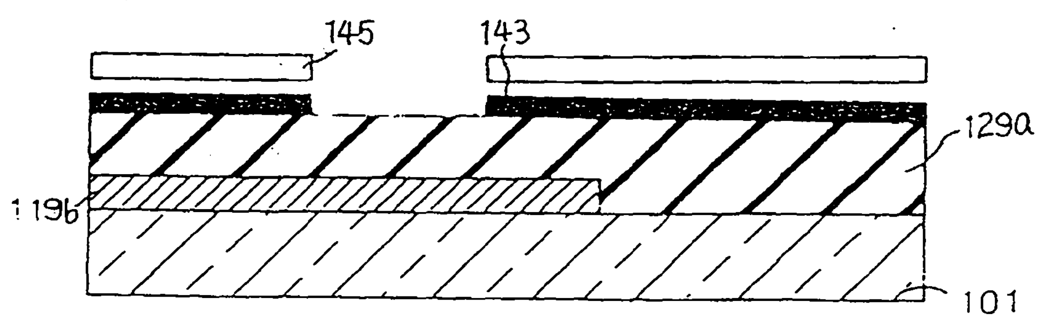


FIG. 8D

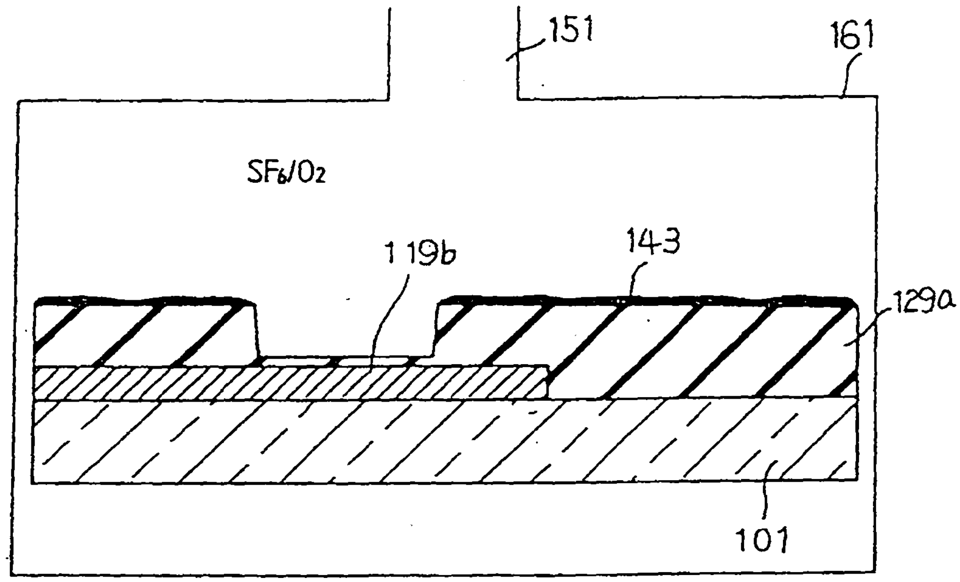

151
161
SF6/O2
119b
143
129a
101

FIG. 8E

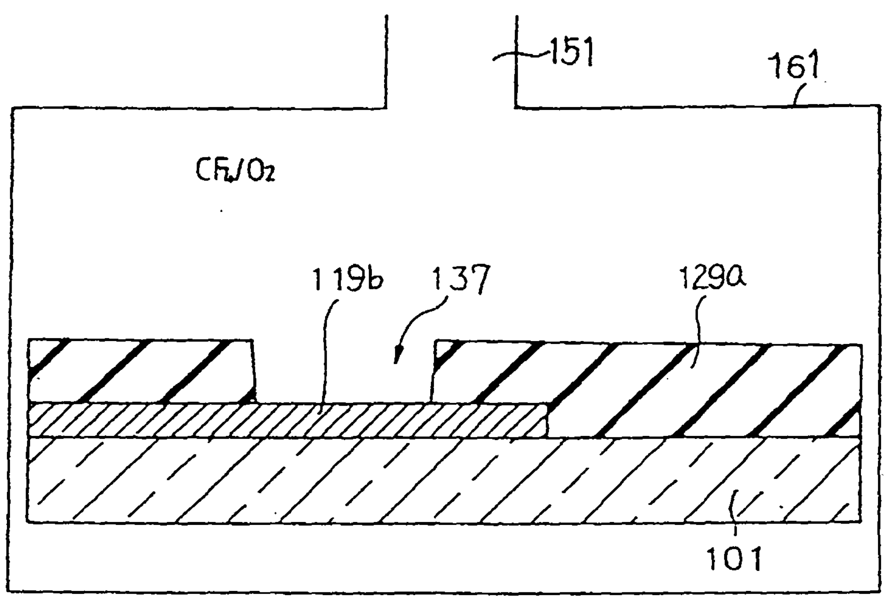

151
161
CF4/O2
119b
137
129a
101

FIG. 8F

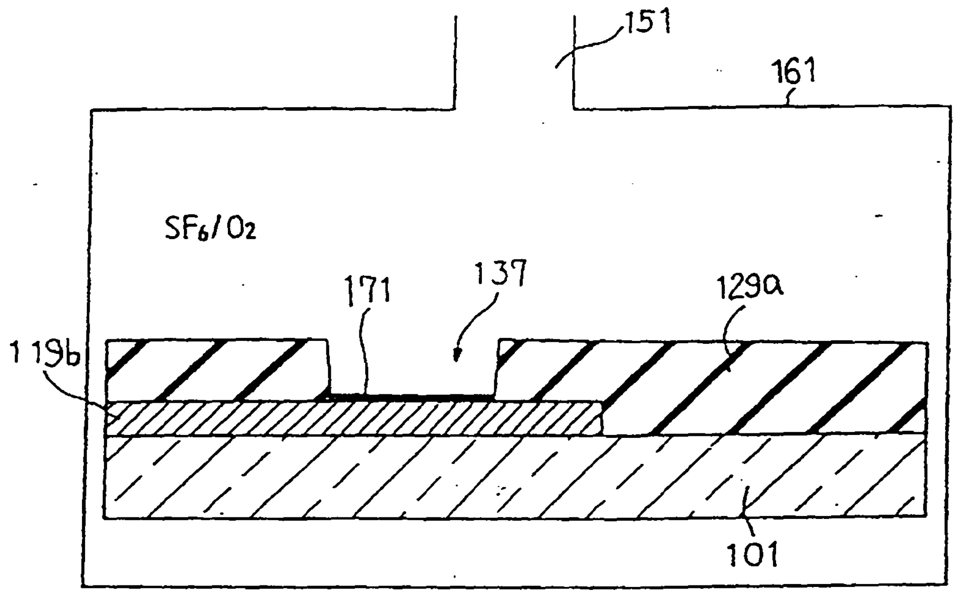
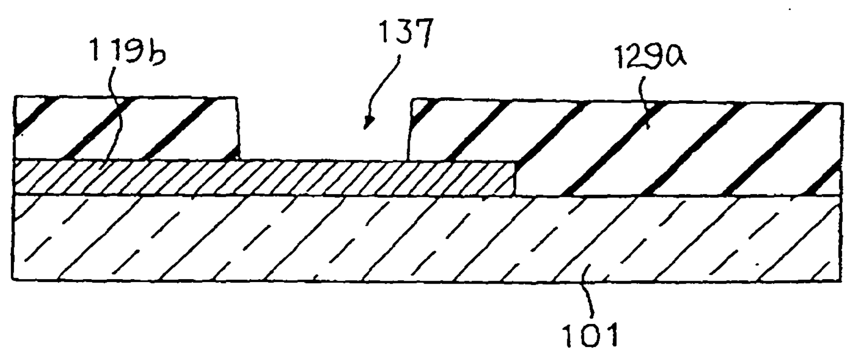


FIG. 8G



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ORGANIC MATERIAL ETCHING METHOD

The present invention relates to a method of etching an organic material, and more particularly, but not exclusively, to a method of forming a hole in an organic material for a liquid crystal display (LCD).

In general, a liquid crystal display (LCD) has two substrates (first substrate and second substrate) facing each other and a liquid crystal material is injected into the gap between the two substrates. Referring to FIG. 1 and FIG. 2, the structure of a conventional LCD is described in detail.

The first substrate has the following structure. A plurality of pixel electrodes 15 are formed at predetermined positions on a transparent substrate 1 so as to form a pixel array. A plurality of data lines 19 carrying display data are formed along columns of the pixel array. A plurality of gate lines 21 are formed along rows of the pixel array. In the case of an active matrix LCD, a switching element 7 is formed at a corner of each pixel and electrically connected to the gate line 21 and the data line 19. The switching element 7 transfers a display data from the data line 19 to the pixel electrode 15 when a sufficient voltage is applied to the gate line 21.

The second substrate has the following structure. A common electrode 17 is formed on a transparent substrate 3 so as to be aligned with the pixel electrodes 15 formed on the first substrate. In a color LCD, a plurality of color filters (not shown in the drawings) are also formed.

The first and second substrates are coupled by a sealing material 13 so as to face each other with a uniform gap. In an LCD having the above-mentioned structure, a switching element 7

is turned on when a voltage is applied to the gate line 21 connected to the switching element 7. The switching element 7 then transfers a data from the data line 19 to the pixel electrode 15, thereby creating a voltage difference between the pixel electrode 15 and the common electrode 17. Then, tilting angle of the liquid crystal material between the pixel electrode 7 and the common electrode changes. Accordingly, polarization state can be controlled. Therefore, the data is displayed according to the control of the light transmission with an appropriate arrangement of polarizers.

There are many types of LCDs, with different structures and materials. Among others, an LCD having an organic layer has been developed in order to ensure a uniform gap between the first and second substrates and enhance the aperture ratio of the LCD. Patent applications have been filed in Korea regarding structures and manufacturing methods for an LCD having an organic layer (96-08344, 96-23296, 96-23295, 96-23448, 96-22404, 96-27653, 96-27655, 96-10414).

In the following, an LCD having an organic layer will be described. In general, an organic layer is used in the first substrate including switching elements. Referring to FIG. 2 and FIG. 3, we describe the case of having thin film transistors (TFTs) as switching elements.

On a transparent substrate 1, a gate line 21 and a gate electrode 21a are formed. A gate insulating layer 23 is formed over the substrate 1 so as to cover the gate line 21 and the gate electrode 21a. On the gate insulating layer 23, a semiconductor layer 25 and an impurity-doped semiconductor layer 27 are formed. A source electrode 19a and a drain electrode 19b are formed and connected to the semiconductor layer 25 through the impurity-

doped semiconductor layer 27. A data line 19 is formed at the same time as the source and drain electrodes 19a , 19b and connected to the source electrode 19a. This completes a TFT 7. Next, a passivation (or insulation) layer 29 is formed to protect the TFT.

Here, the material for the passivation layer is an organic material including Si, such as benzocyclobutene. Therefore, this layer may be called as an organic passivation layer.

A contact hole 37 is formed by etching a portion of the organic passivation layer 29 located over the drain electrode 19b to expose a portion of the drain electrode 19b. A pixel electrode 15 is formed by depositing and patterning a transparent conductive material formed on the organic passivation layer 29, and electrically connected to the drain electrode 19b through the hole 37.

The method of etching the organic passivation layer is a dry etching method by which the passivation layer changes into a volatile material by reaction with free radicals of a plasma gas, and will be described below with reference to FIGs. 4A and 4B.

In FIGs. 4A and 4B, the organic passivation layer 29, the drain electrode 19b, and the substrate 1 are shown. On the organic passivation layer 29, a photoresist 43 is coated and developed to form a predetermined pattern. Then, the substrate 1 is introduced into a vacuum chamber 61. A plasma gas of CF_4/O_2 or SF_6/O_2 is injected into the chamber 61 through a gas inlet 51 (FIG. 4A). Subsequently, the exposed portion of the organic passivation layer 29 (a portion not covered by the developed photoresist 43) is etched by changing the organic passivation layer 29 into SiF_4 by chemical reaction with F radicals of CF_4 or SF_6. Meanwhile, the photoresist 43 is ashed by an O_2 gas

contained in CF_4/O_2 or SF_6/O_2. That is, the photoresist and the exposed portion of the organic passivation layer are simultaneously etched. This conventional method of etching the organic layer has the following problems.

The first problem relates to the photoresist. Because the etching rate of the organic passivation layer and that of the photoresist are almost the same, the thickness of the photoresist 43 must be about the same as that of the organic passivation layer. For example, if the thickness of the organic layer is about 2μm, then the thickness of the photoresist must be equal to or greater than 2μm. Such a thick photoresist cannot be coated uniformly or developed properly. Therefore, after the etching process, the photoresist 43 cannot be removed perfectly and remains on the organic passivation layer 29 (FIG. 4B). Moreover, it is difficult to obtain a good etch profile.

The second problem relates to the surface of the drain electrode. In general, the drain electrode is made of a metal such as Cr. When the organic layer is etched by SF_6/O_2, the contact resistance through the surface of Cr becomes undesirably high. This causes a problem in that a good electrical contact between the pixel electrode and the drain electrode can not be obtained. On the other hand, when the organic layer is etched by CF_4/O_2, this problem does not occur. However, the etching time for a CF_4/O_2 gas is longer than that for a SF_6/O_2 gas. Thus, the manufacturing time of the LCD becomes longer and the manufacturing cost becomes higher.

FIG. 5 shows an experimental result of the contact resistance of the Cr surface. Curve A represents the current-voltage characteristics of the Cr surface when CF_4/O_2 is used. Curve B represents the current-voltage characteristics of the Cr

surface when SF_6/O_2 is used. Curve A clearly has a lower resistance. The possible cause of this phenomenon is as follows. When an SF_6/O_2 gas is used, an oxidized layer may be formed on the Cr surface since Cr reacts with the O_2 gas. On the other hand, when the etching step is performed by CF_4/O_2, the oxidized layer is not easily formed because the O_2 gas reacts with C of CF_4 and produces CO_2 or CO.

Accordingly, the present invention is directed to an etching method for a device having an organic material that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide an improved etching method for an organic layer.

Another object of the present invention is to reduce the number of steps for forming an LCD.

A further object of this invention is to provide an etching method in which the etching time is shortened without sacrificing contact resistance.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a method for manufacturing a device including a thin film of organic material having an Si bonding

structure by etching the organic film comprises the steps of coating a photoresist on the organic film; developing the photoresist using a mask having a predetermined pattern; and etching the device having the photoresist using a plasma gas.

In another aspect of the present invention, a method for manufacturing a device including a thin film of organic material having an Si bonding structure by etching the organic film, comprises the steps of depositing an insulating layer on the organic film; coating a photoresist on the insulating layer; developing the photoresist using a mask having a predetermined pattern; and etching the device having the photoresist using a plasma gas.

In another aspect of the present invention, a method for manufacturing a liquid crystal display having a film type switching element formed on a substrate comprises the steps of forming an organic film by coating an organic material having a Si bonding structure; coating a photoresist on the organic film; developing the photoresist using a mask having a predetermined pattern; and etching the organic film using plasma gases comprising a gas having F radical and O_2 gas.

In another aspect of the present invention, a method for manufacturing a liquid crystal display having a film type switching element formed on a substrate comprises the steps of forming an organic film by coating an organic material having a Si bonding structure; forming an insulating layer by depositing an inorganic material on the organic film; coating a photoresist on the inorganic film; developing the photoresist using a mask having a predetermined pattern; and etching the organic film using plasma gases including a gas having F radical and O_2 gas.

In another aspect of the present invention, a method for manufacturing a liquid crystal display having a film type switching element formed on a substrate comprises the steps of forming an organic film by coating an organic material having a Si bonding structure; coating a photoresist on the organic film; developing the photoresist using a mask having a predetermined pattern; etching the organic film revealed by developed photoresist until the etched amount is up to 2/3 of initial thickness using a plasma gas comprising SF_6 and O_2 gas; and etching the organic film revealed by developed photoresist until the organic film is etched perfectly using a plasma gas comprising CF_4 and O_2 gas.

In another aspect of the present invention, a method for manufacturing a liquid crystal display having a switching element including a gate electrode, a source electrode, and a drain electrode on a substrate, comprises the steps of forming an organic film by coating an organic material having a Si bonding structure; coating a photoresist on the organic film; developing the photoresist using a mask having a predetermined pattern; forming a contact hole by etching the organic film revealed by developed photoresist perfectly using a plasma gas comprising SF_6 and O_2 gas; and soaking the revealed drain electrode through the contact hole into an etchant.

In another aspect of the present invention, a method of forming a hole in an organic layer includes the steps of forming the organic layer; forming an insulating layer over the organic layer; forming a photoresist pattern over the insulating layer; removing a portion of the insulating layer corresponding to the photoresist pattern; and removing a

portion of the organic layer corresponding to the removed portion of the insulating layer to form the hole.

In another aspect of the present invention, a method of forming a hole in an organic layer for an LCD, includes the steps of forming the organic layer; forming a photoresist pattern over the organic layer; removing a portion of the organic layer corresponding to the photoresist pattern using a first etching gas; and removing a remaining portion of the organic layer corresponding to the photoresist pattern using a second etchant.

In another aspect of the present invention, a method of forming a hole in an organic layer formed on a metal layer for an LCD includes the steps of forming the metal layer; forming the organic layer on the metal; forming a photoresist pattern over the organic layer; removing the organic layer corresponding to the photoresist pattern using a first etchant, the organic layer being etched up to a surface of the metal layer; and cleaning the surface of the metal layer using a second etchant.

In a further aspect of the present invention, a method of making a hole in a first layer formed on a substrate comprises the steps of forming a second layer on the first layer; forming a photoresist layer on the second layer, the photoresist layer having an opening; etching the photoresist layer and a portion of the second layer corresponding to the photoresist opening by exposing the substrate to a first etchant, until the portion of the second layer corresponding to the photoresist opening is etched up to a surface of the first layer, wherein a portion of the photoresist layer remains on the second layer when the portion of the second layer

layer corresponding to the photoresist opening is etched up to the surface of the first layer; etching the photoresist layer and a portion of the first layer corresponding to the photoresist opening by exposing the substrate to a second etchant until the photoresist layer is etched up to a surface of the second layer, wherein a portion of the first layer remains in a region corresponding the photoresist opening when the photoresist layer is etched up to the surface of the second layer; and etching the second layer and a portion of the first layer corresponding to the photoresist opening by exposing the substrate to a third etchant until the portion of the first layer corresponding to the photoresist opening is etched up to a bottom of the first layer, wherein when the portion of the first layer corresponding to the photoresist opening is etched up to a bottom of the first layer, there is the second layer left on the first layer.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

For a better understanding of the invention, embodiments will now be described by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a cross-sectional view showing the structure of a conventional LCD;

FIG. 2 is an enlarged plan view showing the conventional LCD having a passivation layer made of an organic material;

FIG. 3 is a cross-sectional view taken along line I-I of FIG. 2;

FIG. 4A is a cross-sectional view showing a conventional method of etching an organic layer;

FIG. 4B is a cross-sectional view showing a photoresist remaining on an organic layer after the organic layer is etched by the conventional etching method;

FIG. 5 is a graph showing the current-voltage characteristics measured at the surface of Cr, after the organic layer is etched by an SF_6/O_2 or CF_4/O_2 gas;

FIGs. 6A to 6E are cross-sectional views showing an etching method according to a first embodiment of the present invention;

FIG. 7 is a cross-sectional view showing etch profiles according to the first embodiment of the present invention;

FIGs. 8A to 8E are cross-sectional views showing an etching method according to a second embodiment of the present invention; and

FIGs. 8F and 8G are cross-sectional views showing an etching method according to a third embodiment of the present invention.

Referring to FIGs. 6A to 6E and 7, the first preferred embodiment of the present invention is described. A data line 119 and a TFT are formed on a substrate 101. The TFT has a gate electrode 121a, a gate insulating layer 123, and source and drain electrodes 119a, 119b. On the TFT, an organic passivation layer 129a containing Si bond structure such as benzocyclobutene (BCB) is formed. On the organic layer 129a, an inorganic layer 129b is formed of a dielectric material such as SiN_x or SiO_x. The inorganic layer 129b is made thinner than the organic layer 129a (FIG. 6A).

A photoresist 143 is coated on the inorganic layer 129b (FIG. 6B). The photoresist 143 is exposed through a mask 145, developed, and patterned (FIG. 6C). Then, the whole substrate is introduced into a vacuum chamber 161 (FIG. 6D). The inorganic layer 129b and the organic layer 129a are etched by a CF_4/O_2 or SF_6/O_2 gas. At the same time, the photoresist is also ashed by O_2 contained in the gas.

Here, the ratio of CF_4 or SF_6 to O_2 is determined such that the etching rate of the inorganic layer to that of the organic layer is preferably about 1:5. As a result, a contact hole 137 is formed in the organic passivation layer 129a located over a portion of the drain electrode 119b. The inorganic layer 129b remains on the rest of the organic passivation layer 129a (FIG. 6E).

Referring to FIG. 7, etch profiles according to the first embodiment are described in detail. First, the exposed portion of the inorganic layer 129b is etched by amount T_5 by producing an SiF_4 gas as a result of the reaction between the inorganic layer 129b and F radicals of CF_4 or SF_6. Meanwhile, the photoresist 143 is also ashed by amount T_4 by an O_2 gas contained in CF_4/O_2 or SF_6/O_2 (O_2 ashing). Here, the etching rates of the photoresist 143 and the inorganic layer 129b can be controlled by changing the composition ratio of the CF_4 or SF_6 gas to the O_2 gas. Once the photoresist 143 is completely removed by the O_2 ashing, the inorganic layer 129b is etched through a reaction with F radicals in a manner shown by dashed lines of FIG. 7. Meanwhile, the middle portion of the organic layer 129a is etched faster than the inorganic layer 129b, as shown by dashed lines of FIG. 7. As shown in the figure, while the inorganic layer 129b is etched by amount T_1, the organic layer 129a is etched by

a larger amount T_6. Here, the etching profile is controlled by the initial thicknesses of the organic layer 129a and the inorganic layer 129b and the composition ratio of O_2 to the CF_4 or SF_6 gas.

As a result, the photoresist 143 and the inorganic layer 129b are etched altogether by amount T_7 at a region where the photoresist was originally coated. The inorganic layer 129b and the organic layer 129a are etched by amount T_2 at a region where the photoresist 143 is not present. Thus, a contact hole 137 is formed in the organic layer 129a located over the drain electrode 119b, and the inorganic layer located on the rest of the organic layer has a thickness T_3 as shown in FIG. 7.

According to the first preferred embodiment, an additional step of removing the photoresist 143 is not necessary, because the photoresist 143 is completely removed during the process of forming the contact hole in the organic passivation layer. Because of the remaining inorganic layer 129b, a conductive material for pixel electrodes can be deposited stably over the organic passivation layer 129a. However, if desired, the inorganic layer can be removed completely by adjusting the ratio of the etching rate of the inorganic 129b to the etching rate of the organic layer 129a or varying the thickness ratio between them.

Second Preferred Embodiment

Referring to FIGs. 8A to 8E, the second preferred embodiment of the present invention is described. As in the first preferred embodiment, a data line and a TFT are formed on a substrate 101. The TFT has a gate electrode, a gate insulating layer, a source electrode, and a drain electrodes 119b. On the TFT, an organic

passivation layer 129a containing Si bond structure such as benzocyclobutene (BCB) is formed (FIG. 8A).

A photoresist 143 is coated on the organic layer 129a (FIG. 8B). The photoresist 143 is exposed through a mask 145, developed, and patterned (FIG. 8C). The whole substrate is introduced into a vacuum chamber 161. An SF_6/O_2 gas is injected through an inlet 151 and brought into a plasma state. The photoresist 143 is ashed by O_2 contained in the SF_6/O_2 gas. The organic passivation layer 129a, in a region where the photoresist is not present, is etched through a reaction of Si with F radicals of SF_6 which produces a SiF_4 gas. The etching process is continued until a thin layer of the organic passivation layer 129a remains (FIG 8D). Then, a CF_4/O_2 gas in a plasma state is injected into the vacuum chamber 161, replacing SiF_4 by CF_4/O_2 gas, through the gas inlet 151. The residual photoresist 143 and the remaining organic passivation layer 129a are simultaneously etched. As a result, the photoresist 143 is completely ashed and a contact hole 137 is formed over the drain electrode 119b (FIG 8E).

Using an SF_6/O_2 gas, the first etching step is quickly performed and the manufacturing time is reduced. A thin layer of the organic passivation layer 129a remaining in the first etching step is etched by CF_4/O_2. Therefore, contact resistance of the drain electrode 119b can be improved.

Third Preferred Embodiment

Referring to FIGs. 8F and 8G, the third preferred embodiment of the present invention is described. As in the second preferred embodiment, the organic passivation layer 129a is etched by the SF_6/O_2 gas in a vacuum chamber 161. However, in the third preferred embodiment, the photoresist 143 and the organic passivation layer 129a are both completely etched at once until a metal surface (Cr, for example) of the drain electrode 119b is exposed (FIG. 8F). Here, the contact resistance would become high since an impurity layer 171 or the like is formed at the Cr surface. Therefore, the impurity layer 171 must be removed by a separate etching process (or cleaning process) using an appropriate wet or dry etchant. The result substrate may be soaked in an etchant, for example, BHF (buffered hydrogen fluorine) or BOE (buffered oxide etchant), or a dry etching method, for example, $Bcl_3 + O_2$, may be used. Hence, a clean Cr surface is obtained (FIG. 8G).

By using an SF_6/O_2 gas, the etching process can be performed quickly and the manufacturing time is reduced. Since the impurity layer 171 is removed by an additional etching process, the contact resistance of the drain electrode 119b is improved.

The present invention relates to a method of etching an organic layer having a Si bond structure. The present invention does not require an additional process of removing a photoresist. This is because the photoresist is burned away by an O_2 gas contained in the etching gas. These effects are achieved by controlling the composition ratio of a CF_4 (or SF_6) gas to the O_2 gas. Furthermore, the contact characteristics between metal and pixel electrodes are improved because an impurity layer such as an oxide layer does not exist at the interface. This result is

due to the two-step process; first, the organic layer is etched by SF_6/O_2 and then the residual organic layer or an impurity layer is removed. Therefore, it becomes possible to manufacture a high performance LCD with a shorter etching (processing) time.

Thus, the present invention provides an etching method for an organic material where an inorganic material is deposited on the organic material. First, the photoresist is coated and developed, and then, the organic and inorganic material are etched while the photoresist is burned away by a CF_4/O_2 (or SF_6/O_2) gas. Another method is that the organic material and the photoresist are etched by SF_6/O_2 gas until a small amount of the organic material remains, and then, the remaining organic material and photoresist are etched by CF_4/O_2. Still another method is that the organic material and the photoresist are etched completely by an SF_6/O_2 gas and then, the impurity layer on the revealed metal is etched by a metal etchant or a dry etching.

In the present invention, in order to obtain a good etching profile of the organic layer, an inorganic layer is deposited on the organic layer. Then, a photoresist is coated on the inorganic layer, and the photoresist is developed. Subsequently, they are etched by a CF_4/O_2 or SF_6/O_2 gas. While the photoresist is burned away by O_2 gas, the inorganic layer and organic layer are simultaneously etched by CF_4 or SF_6 gas. Controlling the etching rate by changing the composition ratio of CF_4 (or SF_6) gas to O_2 gas can remove the photoresist perfectly by the O_2 gas and obtain a good etching profile of the organic layer. Additionally, the remaining amount of the inorganic layer can be controlled on the organic layer by the present invention. Thus,

it becomes possible to have a good adhesion property for a material to be deposited thereon.

On the other hand, an impurity layer formed on the metal surface (Cr surface, for example) during the etching process of the organic layer can be removed according to the present invention. According to this invention, the organic layer is etched by SF_6/O_2 gas until a small amount remains, and then the remaining organic layer is etched by CF_4/O_2 gas. There is no impurity layer on the metal layer. In another method, the organic layer is etched perfectly by SF_6/O_2, then the impurity layer is removed by a metal etchant or a dry etching. Therefore, a layer to be deposited thereon makes a good electrical contact with the metal layer.

It will be apparent to those skilled in the art that various modifications and variations can be made in the etching method for a device having an organic material of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

Claims:

1. A method of forming a hole in an organic layer, the method comprising the steps of:

forming the organic layer;

forming an insulating layer over the organic layer;

forming a photoresist layer over the insulating layer, the photoresist layer having an opening;

removing the photoresist layer and a portion of the insulating layer corresponding to the photoresist opening; and

removing a portion of the organic layer corresponding to the removed portion of the insulating layer to form the hole.

2. The method according to claim 1, wherein the organic layer in the organic layer forming step includes Si bond structure.

3. The method according to claim 1 or 2, wherein the organic layer includes benzocyclobutene.

4. The method according to claim 1, 2 or 3, wherein the insulating layer in the insulating layer forming step includes an inorganic material.

5. The method according to claim 4, wherein the inorganic material includes one of SiN_x and SiO_x.

6. The method according to claim 1, 2, 3, 4 or 5, wherein the insulating layer removing step and the organic

layer removing step use a same etchant, the etchant including F radicals and O_2.

7. The method according to any one of claims 1 to 6, wherein the etchant includes CF_4.

8. The method according to any one of claims 1 to 6, wherein the etchant includes SF_6.

9. A method of forming a hole in an organic layer for an LCD, the method comprising the steps of:

forming the organic layer;

forming a photoresist layer over the organic layer, the photoresist layer having an opening;

removing a portion of the photoresist layer and a portion of the organic layer corresponding to the photoresist opening using a first etching gas; and

removing the residual photoresist layer and a remaining portion of the organic layer corresponding to the photoresist opening using a second etching gas.

10. The method according to claim 9, wherein the organic layer in the organic layer forming step includes Si bond structure.

11. The method according to claim 9 or 10, wherein the organic layer in the organic layer forming step includes benzocyclobutene.

12. The method according to according to claim 9, 10 or 11, wherein the first etching gas includes SF_6/O_2.

13. The method according to according to claim 9, 10 or 11, wherein the second etching gas includes CF_4/O_2.

14. The method according to claim 9, 10, 11, 12 or 13, wherein the first etching gas has a first etch rate and the second etching gas has a second etch rate.

15. The method according to claim 14, wherein the first etch rate is higher than the second etch rate.

16. A method of forming a hole in an organic layer formed on a metal layer for an LCD, the method comprising the steps of:

forming the metal layer;

forming the organic layer on the metal;

forming a photoresist layer over the organic layer, the photoresist layer having an opening;

removing the photoresist layer and the organic layer corresponding to the photoresist opening completely using a first etching gas, the organic layer being etched up to a surface of the metal layer; and

cleaning the surface of the metal layer using a second etching gas.

17. The method according to claim 16, wherein the metal layer includes Cr.

18. The method according to claim 16 or 17, wherein the organic layer in the organic layer forming step includes Si bond structure.

19. The method according to claim 16, 17 or 18, wherein the organic layer includes benzocyclobutene.

20. The method according to claim 16, 17, 18 or 19, wherein the first etching gas includes SF_6/O_2.

21. The method according to claim 16, 17, 18 or 19, wherein the second etchant includes CF_4/O_2.

22. The method according to any one of claims 16 to 21, further comprising the steps of:

forming an inorganic layer between the organic material forming step and the photoresist layer forming step; and

removing the inorganic layer corresponding to the photoresist opening between the photoresist layer forming step and the organic layer removing step,

wherein the photoresist layer in the photoresist layer forming step is formed on the inorganic layer.

23. The method according to claim 22, wherein the inorganic layer includes one of SiN_x and SiO_x.

24. A method of making a hole in a first layer formed on a substrate, the method comprising the steps of:

(a) forming a second layer on the first layer;

(b) forming a photoresist layer on the second layer, the photoresist layer having an opening and a photoresist pattern,

wherein the photoresist opening defines a first portion of the first layer and a first portion of the second layer, and

the photoresist pattern defines a second portion of the first layer and a second portion of the second layer;

(c) etching the photoresist pattern and the first portion of the second layer by exposing the substrate to a first etching gas until the first portion of the second layer is etched up to a surface of the first portion of the first layer,

wherein a portion of the photoresist pattern remains on the second portion of the second layer when the first portion of the second layer is etched up to the surface of the first portion of the first layer;

(d) etching the first portion of the first layer and the photoresist pattern remaining on the second portion of the second layer by exposing the substrate to a second etching gas until the photoresist pattern remaining on the second portion of the second layer is etched up to a surface of the second portion of the second layer,

wherein the first portion of the first layer remains in a region corresponding to the photoresist opening when the photoresist pattern remaining on the second portion of the

second layer is etched up to the surface of the second portion of the second layer; and

(e) etching the second portion of the second layer and the first portion of the first layer remaining in the region corresponding to the photoresist opening by exposing the substrate to a third etching gas until the first portion of the first layer remaining in the region corresponding to the photoresist opening is etched up to a bottom of the first portion of the first layer,

wherein the second portion of the second layer remains on the second portion of the first layer when the first portion of the first layer remaining in the region corresponding to the photoresist opening is etched up to the bottom of the first portion of the first layer.

25. The method according to claim 24, wherein in the step (e), an etch rate of the first layer by the third etching gas is higher than an etch rate of the second layer by the third etching gas.

26. The method according to claim 24 or 25, wherein the first etching gas, the second etching gas, and the third etching gas are a substantially same etching gas.

27. The method according to claim 26, wherein the substantially same etching gas includes SF_6/O_2.

28. The method according to claim 26, wherein the substantially same etching gas includes CF_4/O_2.

29. The method according to claim 24, 25, 26, 27 or 28, wherein the first layer includes an organic layer and the second layer includes an inorganic layer.

30. The method according to claim 29, wherein the organic layer includes benzocyclobutene.

31. A method substantially as hereinbefore described with reference to and/or as illustrated in any one of or any combination of Figs. 6A to 8G of the accompanying drawings.

The Patent Office

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Application No: GB 9714116.2
Claims searched: 1-8

Examiner: Graham Russell
Date of search: 26 September 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B6J (JMY, JP)

Int Cl (Ed.6): H01L 21/311

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 0145911 A2	(IBM) see page 1 lines 14-23	1
A	WO 87/02626 A1	(TANDEM) see page 7 lines 10-31	1,7,8
X	US 5453157	(TEXAS) see column 3 lines 34-62	1,2,4,5
A	US 4687543	(TEGAL) see column 3 lines 14-40	1,8

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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